The effect of counterforce bracing on grip strength in tennis players with painful elbows

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Counterforce bracing is considered to change the mechanical origin of the forearm extensors, thereby decreasing the force of internally generated muscle tension. A clinical study was conducted of 19 tennis players complaining of elbow pain. Seventeen had previously used some form of counterforce bracing for symptomatic pain relief.

In those with symptomatic arms, no significant difference in grip strength with or without the brace was identified. Similarly, no significant differences were recorded in the non-symptomatic arms, with or without the braceThere was also no significant difference between the symptomatic and non-symptomatic arms, when grip strength was compared with and without the brace.

The frequent use of counterforce bracing suggests bracing may subjectively reduce symptoms of pain. However, the results of this study demonstrate that it has no effect on objective measures of grip strength.

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At some time in their careers, 40 to 50 per cent of tennis players develop pain about the elbow (Groppel and Nirschl 1986). One explanation for this predisposition to injury may be the predominant activity of the wrist extensors in all strokes used in the game. (Morris et al 1989, Curwin and Stanish 1984). Most of the symptoms arise from the lateral extensor muscle origin or from the lateral epicondyle, and only about 10 per cent come from the medial epicondyle (Morris et al 1989). Priest, Braden and Gerberich (1980) state that only pain on the lateral aspect of the elbow should be considered as classic tennis elbow.

The muscles of the forearm help to stabilise the elbow and the wrist as a unit during the strokes in tennis. The greatest muscle activity during the execution of ground strokes is in those muscles that stabilise the wrist, primarily extensor carpi radialis longus and brevis (Morris et al 1989). The wrist extensors have a common attachment to the lateral epicondyle via the extensor aponeurosis, the common extensor origin.

The usual activity of the wrist extensors is synergistic, the finger flexors contracting simultaneously with wrist extension (Curwin and Stanish 1984). The positioning of the wrist in extension allows a much more powerful grip. This stabilising action of the wrist extensors means that they are active in virtually all activities requiring use of the hand.

In order to stabilise the racket limb prior to impact in a forehand drive, an elbow angle of 139° has been recorded by Elliott, Marsh and Overheu (1988). Elbow angles of 162° and 167° for players such as Nastase and Evert have been reported at impact (Ariel and Braden 1979). Marked activity of the wrist extensors is also seen in the service action.

During a serve, extensor carpi radialis longus and brevis and extensor digitorum all show maximum activity in the wrist-cocking phase. This constant level of activity may be one factor which predisposes these muscles to injury. Other factors which may be considered to contribute to this type of injury are abnormal muscle activity or an improper sequence of muscle activation.

Previous studies of tennis elbow have identified a wide variety of causes including local trauma, contusion or sprain, soft tissue calcification, bursitis, radiohumeral synovitis, tearing of the extensor carpi radialis brevis muscle, avulsion of the tendon origin, displacement of the orbicular ligament on the radial head and idiopathic spontaneous occurrence (Ilfeld and Field 1966).

Tears occurring in the tenoperiosteal junction of the extensor carpi radialis

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brevis account for 90 per cent of tennis elbow injuries (Cyriax 1975). Extensor digitorum longus is involved to a lesser extent. Degenerative changes are also considered to play a major role in the etiology of tennis elbow.

Since tennis elbow is more prevalent in players who have been playing for a longer period of time, it has been proposed that the condition may be related to the aging process (Gruchow and Pelletier 1979, Priest et al. 1980). The use of an oversized aluminium racquet, and having begun tennis in the third rather than the second decade of life (Kamien 1989) have been reported to be significant aggravating factors in the development of tennis elbow

The prime etiologic factor appears to be a force overload at the aponeurosis (Nirschl 1973). The causative factors may be classified as intrinsic overload (muscle contracture) or extrinsic overload (outside force/stretch injury). Surgical studies have clearly identified classic tennis elbow as tendonitis, which can be divided into lateral, medial and posterior areas (Nirschl and Sobel 1981).

Cervical spine problems have also been reported to be associated with the condition, as some degree of cervical degeneration preceding tennis elbow has been reported in many patients (Gunn and Milbrandt 1976).

The symptoms of tennis elbow are pain on strong gripping action and weakness of the grip as a result of pain. Signs include tenderness to pressure on the point of the lateral epicondyle, pain and weakness with resisted wrist extension, and pain on stretching of the wrist extensors (Curwin and Stanish 1984, Harvey et al 1990).

Treatment regimens

Most methods of treatment of tennis elbow have in common the objective of reduction of tension in the common extensor origin on the lateral humeral epicondyle (Froimson 1971). Success with the use of an upper forearm brace, known as a counterforce brace, in the management of tennis elbow has been documented (Burton 1985, Froimson 1971, Ilfeld and Field 1966, Nirschl 1973). However, Gruchow and Pelletier (1979) have questioned the effectiveness of these devices.

These authors indicated that, although a forearm brace may temporarily reduce the symptomatic pain of tennis elbow, it encourages players to continue excessive use of the elbow both in playing tennis and in other activities. Snyder-Mackler and Epler (1989) reported no significant difference in muscle activity when using a standard counterforce brace in normal subjects. However, these results should be interpreted with caution as only a small sample of normal subjects was analysed.

A counterforce brace is a non-elastic support which constrains full muscle expansion when the muscle contracts, minimises exaggerated tendon movement, and diminishes the potential force generated by the muscle. Testing using a Cybex isokinetic dynamometer has confirmed the clinical validity of this concept (Nirschl and Sobel 1981).

In most cases, the overload force is a small percentage of the total force generated, so the total force has to be contained only to a point below the injury-producing level. This small reduction, however, becomes meaningful when it is magnified by thousands of repetitions. Positive biomechanical alterations in forearm muscle activity with the use of a forearm brace have been reported (Groppel 1986). Additional wrist straps or connecting bars have not proved useful (Nirschl and Sobel 1981).

With counterforce bracing, the extensor muscle mass is supplied with a second origin distal to the radial head and the fulcrum leverage effect that occurs at the attachment of the aponeurosis to the lateral epicondyle is decreased. This, in turn, changes the mechanical origin of the extensors (Nirschl 1973, Stonecipher et al 1984).

This technique either decreases the quantity of internally-generated muscle tension or directs overload force to less sensitive tissue or to the brace itself. The counterforce brace provides mechanical support, protecting the common extensor origin from further strain. Any existing inflammatory reaction producing pain may therefore subside and healing can occur. In addition, there is a reflex reduction in pain allowing greater grip strength (Burton 1985).

This study aimed to determine the effect of counterforce bracing on grip strength in tennis players with elbow pain. It is based on a previous study by Burton(1985), which quantified increases in grip strength, and hence antagonistic extensor strength, in subjects with tennis elbow wearing a forearm brace.

Method

Subjects

Nineteen tennis players (3 males, 16 females) participated in the study. Criteria for inclusion in the study required at least one episode of elbow pain in the four weeks prior to commencement of the study. Subjects were volunteers from two local tennis clubs in Perth, and testing was performed at the end of the competitive tennis season.

Apparatus

An ACE tennis elbow brace, manufactured by Becton Dickinson and Company, Rochelle Park, New Jersey, was the model of counterforce bracing used in the study (see Figure 1). The brace is available in small, medium and large sizes.

A brace of appropriate size, fitted to the size of the forearm musculature, was selected for each subject. When fitted, the brace should be totally comfortable with the forearm musculature relaxed. Only when the muscle contracts and expands should the user note any tension between the forearm and the brace. All subjects were instructed to adjust the tension appropriately to prevent discomfort.

Grip strength was tested with a dynamometer. A Jamar adjustable dynamometer (Marsh Instrument Company, Asimow Engineering

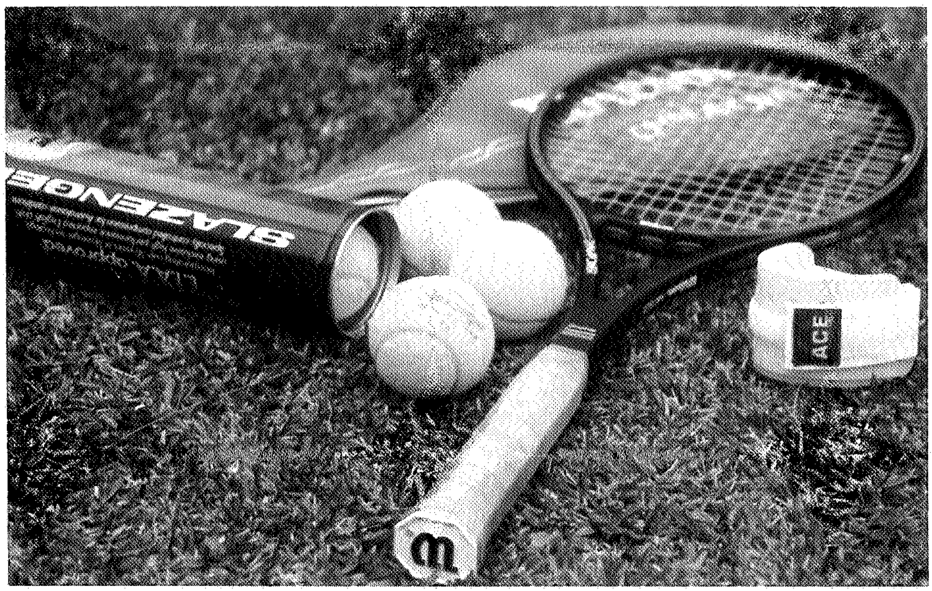

Figure 1
The model of counterforce bracing used in the study.

Company, Los Angeles, California, was used to record the dependent variable (Figure 2). The range in pressure of the device was 0 to 200 dynamometer pressure units.

Procedure

The subjects were first asked to complete a questionnaire which was designed to gather essential descriptive data. The information recorded included the subject's gender, age, level of tennis, and the area, duration, intensity and treatment of any elbow pain.

The study involved testing grip strength of the right and left arm, with and without the counterforce brace in situ. Each subject performed five tests of grip strength in each of these four conditions. Measurements of the painful elbow (symptomatic arm) were analysed as the study group and the contralateral arm results were analysed as the control group (non-symptomatic arm). In this way, the study and the control groups were standardised demographically.

The position in which grip strength was tested was standardised throughout the study. Subjects were seated at a table with the shoulder flexed 45° in the sagittal plane and the elbow at an angle of 150°. The

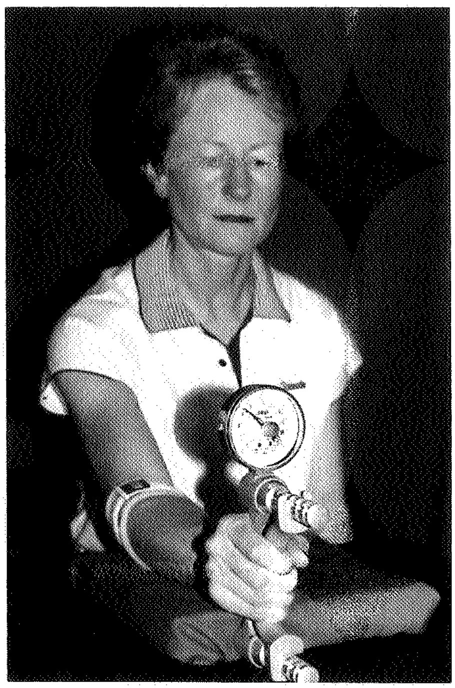

Figure 2
The position in which grip strength was tested.

forearm was in mid-position between supination and pronation, and the wrist in extension. This position was chosen as it most closely resembles impact phase during a ground stroke (Figure 3).

Using the affected arm, subjects were instructed to slowly squeeze the dynamometer maximally and then relax. The maximum pressure obtained was measured. The procedure was repeated five times. This sequence was repeated on the control arm without the brace, and on the affected and control arms with the brace.

The order in which testing was performed was randomised. Each subject selected a card which designated whether they performed the manoeuvre with the right or left arm first, and whether the first test was performed with or without the counterforce brace in situ. As five maximal contractions were required in each of the four positions, this method prevented any learning effect or fatigue which might have biased the results.

Data analysis

Statistical significance was tested using the Wilcoxon Signed-Rank Test to analyse grip strength with and without the brace in the symptomatic group. Again, the Wilcoxon Signed-Rank Test was used to analyse grip strength with and without the brace in the non-symptomatic group.

A further analysis was conducted using the Mann-Whitney U Test to compare the difference in grip strength between the symptomatic and non-symptomatic groups.

A Wilcoxon Signed-Rank Test was used to analyse the grip strength of the symptomatic (dominant) arm and non-symptomatic (non-dominant) arm without the brace. Again, the Wilcoxon Signed-Rank Test was used to analyse the grip strength of the symptomatic (dominant) arm and non-symptomatic (non dominant) arm with the brace.

The level of significance was set at p=0.05 .

Results

The frequency and percentage distribution for the characteristics of tennis players and their elbow pain patterns is shown in Table 1.

The table demonstrates that the

Table 1
Characteristics of tennis players and their elbow pain

GENDER	Male	3	15.8 %
	Female	16	84.2 %
AGE	<40 years	4	20.9 %
	>40 years	15	79.1 %
LEVEL OF TENNIS	A Division	3	15.8 %
	B Division	10	52.6 %
	Social	6	31.6 %
NUMBER OF YEARS PLAYING TENNIS	5-10 years	5	26.3 %
	>10 years	14	73.7 %
SIDE OF ELBOW PAIN	Right	18	94.7 %
	Left	1	5.3 %
SIDE OF RACKET GRIP	Right	18	94.7 %
	Left	1	5.3 %
LOCATION OF PAIN	Inside elbow	2	10.5 %
	Outside elbow	8	42.1 %
	Forearm	3	15.8 %
	Composite	6	31.6 %
DURATION OF ELBOW PAIN	<2 weeks	1	5.5 %
	1-6 months	5	27.8 %
	>6 months	12	66.7 %
HAVE YOU HAD ELBOW PAIN IN THE PAST?	Yes	12	63.2 %
	No	7	36.8 %
IF YES, WHICH ELBOW?	Right	11	91.7 %
	Left	1	8.3 %
IF YES, HOW LONG AGO?	< 6 months	1	8.3 %
	6-12 months	2	16.7 %
	>12 months	9	75.0 %
WHEN DO YOU EXPERIENCE ELBOW PAIN?	Activities	9	50.0 %
	Tennis	8	44.4 %
	Other	1	5.5 %
TREATMENT RECEIVED FOR ELBOW PAIN	Brace	9	47.3 %
	Medication	1	5.3 %
	Other	1	5.3 %
	Composite	8	42.1 %
CLASSIFICATION	Acute	6	35.3 %
	Chronic	9	52.9 %
	Insiduous	2	11.8 %

n=19

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majority of participants in the study were female tennis players aged above 40 years (79.1 per cent) who had been playing tennis for more than 10 years (73.7 per cent) at a competitive level (68.4 per cent).

Eighteen players (94.7 per cent) held the tennis racket with their right hand (94.7 per cent) and also suffered right elbow pain (94.7 per cent). Sixteen players (84.2 per cent) complained of pain at the elbow while 12 players (66.7 per cent) suffered elbow pain for a period of greater than six months.

Twelve players (63.2 per cent) had a history of elbow pain which was predominantly at the right elbow (91.7 per cent) and lasted more than 12 months (75.0 per cent). All players experienced elbow pain in activities with repeated wrist movements (50 per cent) and/or playing tennis (50 per cent).

Seventeen (89.5 per cent) players had tried using some form of elbow brace in the past to provide a symptomatic relief from pain. In all participants, the symptomatic arm was the dominant arm.

Six players (35.3 per cent) classified their elbow injuries as acute, following either direct (to the forearm muscles) or indirect trauma (acute pull of the forearm extensors), while nine players (52.9 per cent) classified their injuries as chronic (repeated and forcible extension of the wrist) and two (11.8 per cent) reported an insidious onset.

No significant difference in grip strength with or without the brace was detected in the symptomatic arm ($Z = -0.684, p = 0.4939$). Similarly, no significant difference in grip strength with or without the brace was identified in the non-symptomatic arm ($Z = -1.791, p = 0.0733$). Therefore, in both the affected and unaffected arms, grip strength was not altered by the use of a counterforce brace.

Comparison was made of the differences in grip strength in both the symptomatic and non symptomatic arms both with and without the brace. An unpaired Mann-Whitney U Test indicated no significant difference between symptomatic and non-symptomatic arms (Z value = -0.789, p = 0.4304) when assessing the differences in grip strength without and with the brace.

However, a significant difference in grip strength between the symptomatic (dominant) arm and non-symptomatic (non-dominant) arm without the brace (Z = -2.637, p = 0.0084) was found. A similar significant difference in grip strength between the symptomatic (dominant) arm and non-symptomatic (non-dominant) arm with the brace (Z = -2.596, p = 0.0094) was found.

Table 2
Grip strength with and without the brace in the symptomatic and non-symptomatic arm

	SYMPTOMATIC ARM		NON -SYMPTOMATIC ARM	
SUB-JECTS	WITHOUT BRACE	WITH BRACE	WITHOUT BRACE	WITH BRACE
1	72.0	75.0	41.0	58.0
2	65.2	62.2	49.2	60.0
3	56.0	49.8	50.0	44.8
4	61.6	62.0	63.8	81.6
5	57.2	61.4	56.6	64.0
6	52.2	50.0	32.6	31.2
7	67.8	67.0	64.4	65.0
8	62.0	66.6	52.0	55.0
9	102.2	97.2	00.0	99.4
10	64.4	67.2	59.4	64.0
11	46.4	60.0	45.8	51.8
12	39.8	44.0	43.4	45.6
13	75.8	74.0	47.4	41.8
14	60.8	90.8	72.0	75.4
15	89.8	84.2	65.2	77.4
16	59.2	67.2	53.0	56.4
17	54.4	44.2	48.2	41.0
18	40.8	40.0	43.2	39.0
19	43.4	49.6	35.0	36.6
X	61.63	63.8	53.80	57.26
S.D.	15.78	15.77	15.29	17.53

Discussion

Some researchers have indicated that tennis elbow may be related to the aging process, and is more prevalent in those players who have been playing for a longer period of time (Gruchow and Pelletier 1979, Priest et al 1980). The characteristics of the sample in the current study would support these findings.

The majority of participants in this study were female tennis players aged more than 40 years who had been playing competitive tennis for more than 10 years. These players also identified varied locations of elbow pain, with 32 per cent reporting composite areas contributing to elbow pain involving the neck and shoulder. Only 42 per cent recorded outside elbow pain. These findings differed from Priest et al (1980) who found that 75 per cent of elbow pain was located over the lateral humeral epicondyle.

Frequently, tennis elbow studies are deficient because the focus is only on the elbow and the relationship between the neck, shoulder and elbow is neglected. However, the findings in this study were similar to those of Gunn and Milbrandt (1976) and Harvey et al (1990) who found that cervical and shoulder assessment was necessary to eliminate any radiculopathy which would be implicated in some elbow pain problems. In addition, this study also found that all tennis players experienced elbow pain in activities with repeated wrist movements and/or playing tennis.

Only 52 per cent of these players classified their elbow pain as chronic whereas Harvey et al (1990) have reported that many tennis players with chronic elbow pain tend not to complete an adequate rehabilitation programme .

Harvey et al (1990) also mentioned that part of the treatment regimen for tennis elbow includes a counterforce brace. Subjective clinical assessment of the effectiveness of this brace was based on the reduction of elbow pain after repeated wrist extension.

The results of our study indicate that counterforce bracing has no effect on grip strength in those tennis players with painful elbows. This conclusion can be drawn since no significant difference in grip strength with and without the brace in the symptomatic arms was identified.

Equally, comparisons between the symptomatic and non-symptomatic arms demonstrated no significant difference when assessing grip strength with and without the brace.

Thus, counterforce bracing was

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found to have no effect on grip strength, and therefore no effect on antagonistic extensor muscle strength.

These findings are similar to those of previous studies which demonstrated no difference in grip strength or extensor muscle activity in non-symptomatic subjects with the use of a counterforce brace (Burton 1985, Snyder-Mackler and Epler 1989). However,the present study did not find increases in grip strength with the use of a forearm brace in symptomatic subjects as reported by Burton (1985).

The wide use of counterforce bracing in the tennis population suggests that the brace may provide some benefit such as a subjective reduction in pain and subsequent enhanced performance. As there is no alteration in grip strength with the use of a counterforce brace in symptomatic subjects, it may be suggested that the brace inhibits pain, allowing normal grip strength.

However, comparisons between grip strength in the symptomatic and non-symptomatic arms without the brace, showed that the symptomatic arms were significantly stronger. The symptomatic group constituted the dominant arm in all 19 subjects and the non-symptomatic group constituted the non-dominant arm. This indicates that pain is not an inhibiting factor in the assessment of grip strength. As this study is comparing the differences in grip strength with and without the brace in situ, differences in grip strength due to arm dominance have no influence on the results.

In view of these findings, an alternative explanation for the efficacy of counterforce bracing could be suggested. The grip strength may be influenced by the facilitation or inhibition of muscle function, however the counterforce brace may act to disperse the force of contraction over a greater surface area, thereby diminishing overload forces at the lateral epicondyle. The brace may also provide mechanical support to the common extensor origin at the lateral epicondyle.

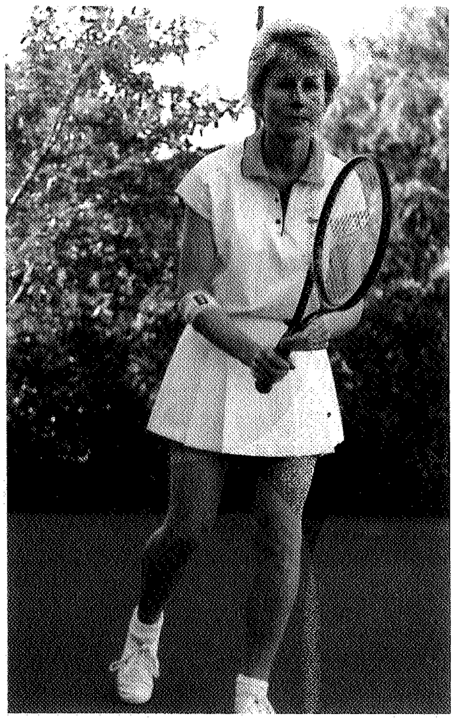

Figure 3
The test position was chosen as it most closely resembles impact phase during a ground stroke

Analysing the effect of counterforce bracing on the tennis players' subjective perception of pain would have been an interesting adjunct to the current study. Pain on strong gripping action or weakness of the grip due to pain are symptoms of tennis elbow.

Conclusion

This study has illustrated that counterforce bracing has no effect on objective measures of grip strength or antagonistic extensor muscle strength in tennis players with painful elbows. However, the frequent use of counterforce bracing by tennis players indicates that there may be other physiological and psychological benefits which could be attributed to the brace. Nevertheless, the results of this study have shown that the proposed biomechanical function of the brace does not necessarily lead to an alteration in grip strength, nor does it appear to inhibit pain in order to facilitate normal grip strength.

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